

**Before the  
FEDERAL COMMUNICATIONS COMMISSION  
Washington, D.C. 20554**

*In the Matter of*

THE ESTABLISHMENT OF POLICIES AND SERVICE RULES FOR  
THE BROADCASTING SATELLITE SERVICE AT THE 17.3-17.7  
GHZ FREQUENCY BAND AND AT THE 17.7-17.8 GHZ  
FREQUENCY BAND INTERNATIONALLY, AND AT THE 24.75-  
25.25 GHZ FREQUENCY BAND FOR FIXED SATELLITE  
SERVICES PROVIDING FEEDER LINKS TO THE  
BROADCASTING-SATELLITE SERVICE AND FOR THE  
BROADCASTING SATELLITE SERVICE OPERATING BI-  
DIRECTIONALLY IN THE 17.3-17.7 GHZ FREQUENCY BAND

IB Docket No. 06-123

**COMMENTS OF DIRECTV, INC.**

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## SUMMARY

As one of four current applicants for 17/24 GHz BSS space station authorizations, DIRECTV eagerly looks forward to the opportunity to use this new spectrum allocation to increase its innovative video offering to consumers throughout the United States.

Although the Commission adopted a number of licensing and service rules earlier this year, the current *FNPRM* seeks comment on remaining issues related to spectrum sharing between 17/24 GHz BSS and DBS operators. In order to resolve these issues, DIRECTV urges the Commission to:

- Require a minimum of 0.4° spacing between 17/24 GHz BSS space stations and operational DBS orbital locations (consistent with a new ITU Recommendation), as well as coordination to the extent off-axis PFD exceeds  $-93 \text{ dBW/m}^2/24 \text{ MHz}$ .
- Grandfather existing DBS uplink facilities within a non-protection zone extending 30 km, and allow the grandfathered operator to implement upgrades within 1 km of those existing facilities.
- Require that new DBS uplink facilities be coordinated with existing 17/24 GHz BSS users, located in areas of very low population density, and be operated within a specified PFD level.

As both a 17/24 GHz BSS applicant and the nation's leading DBS provider, DIRECTV submits that this approach strikes an appropriate balance between protecting existing expectations and protecting a nascent service that offers an exciting opportunity for further development of direct-to-home satellite video services. DIRECTV encourages the Commission to move expeditiously to conclude this proceeding so that this band can be put to productive use as quickly as possible.

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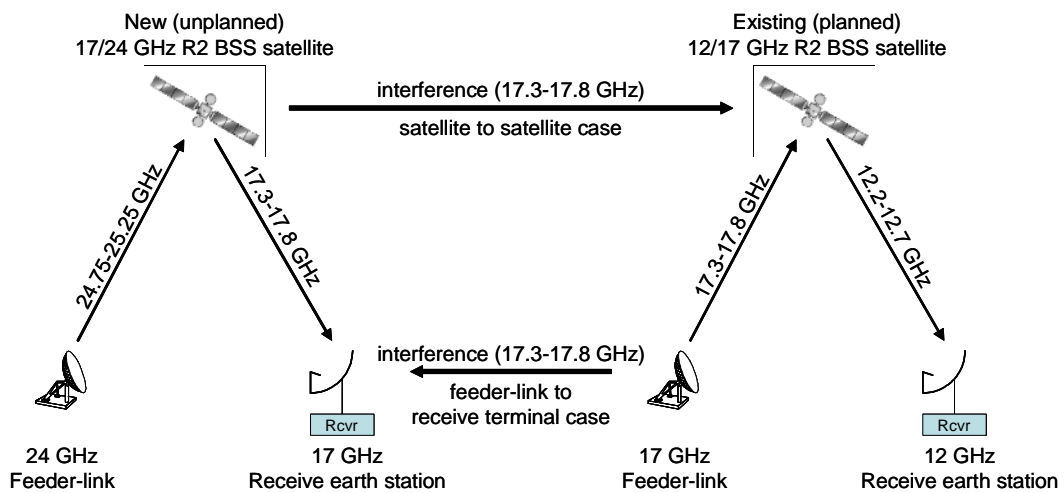
**COMMENTS OF DIRECTV, INC.**

DIRECTV, Inc. (“DIRECTV”), the nation’s leading Direct Broadcast Satellite (“DBS”) service provider, welcomes the opportunity to address the technical and sharing issues raised in the further notice of proposed rulemaking for the Broadcasting Satellite Service (“BSS”) in the 17.3-17.8 GHz and 24.75-25.25 GHz bands (“17/24 GHz BSS”).<sup>1</sup> DIRECTV and others with pending applications for 17/24 GHz BSS authorizations have made clear that this new spectrum allocation creates exciting opportunities for innovative video service offerings to American consumers. DIRECTV urges the Commission to complete this proceeding expeditiously so that 17/24 GHz BSS systems can begin making intensive use of this spectrum as soon as possible.

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<sup>1</sup> See *Establishment of Policies and Service Rules for the Broadcasting Satellite Service at the 17.3-17.7 GHz Frequency Band and at the 17.7-17.8 GHz Frequency Band Internationally, and at the 24.75-25.25 GHz Frequency Band for Fixed Satellite Services Providing Feeder Links to the Broadcasting-Satellite Service and for the Broadcasting Satellite Service Operating Bi-directionally in the 17.3-17.7 GHz Frequency Band*, 22 FCC Rcd. 8842 (2007) (“FNPRM”). The Commission amended certain aspects of the rules adopted in that order in a *Sua Sponte Reconsideration Order*, 22 FCC Rcd. 17951 (2007).

Although the Commission resolved a number of technical and licensing issues in this band earlier this year, the issues deferred to this *FNPRM* proceeding primarily revolve around balancing the needs of both DBS and 17/24 GHz BSS systems to use the 17.3-17.8 GHz band. Specifically, the *FNPRM* raises a series of questions related to potential ground path interference and space path interference between 17/24 GHz BSS systems and DBS systems. As illustrated in Figure 1 below, space path interference concerns potential disruption to DBS satellite receive antennas by 17/24 GHz BSS downlink transmissions, while ground path interference concerns potential disruption to 17/24 GHz BSS receive antennas by DBS uplink transmissions.



**Figure 1. Space Path and Ground Path Interference**

DIRECTV is both a DBS licensee and a 17/24 GHz BSS applicant. It believes that the Commission should protect the reasonable expectations for existing DBS satellites and uplink sites to ensure that service currently enjoyed by tens of millions of American consumers is not disrupted or degraded, but otherwise should minimize the burden DBS operations place on the nascent 17/24 GHz BSS service.

## **I. Space Path Interference**

Here, the concern is that 17/24 GHz BSS space stations transmitting in the 17 GHz band will cause interference to DBS space stations receiving uplink transmissions in this band. Generally speaking, DIRECTV believes that such interference presents a significant problem to the extent that DBS and 17/24 GHz BSS satellites are located in very close proximity. However, given the lack of empirical data on actual operations of such satellites near one another, determining the best way to approach this problem is somewhat problematic. As discussed below, given the tens of millions of Americans who rely upon DBS for their video services, DIRECTV believes that the Commission should take a conservative approach that blends both a required minimum orbital separation and coordination if a 17/24 GHz BSS satellite nevertheless exceeds a specified PFD level into a nearby DBS satellite.

With respect to minimum orbital spacing, the ITU study group dealing with broadcasting issues (which includes the Working Party addressing BSS issues) recently approved a draft Recommendation on this precise issue.<sup>2</sup> Annex 1 to that draft Recommendation includes a model of typical satellite parameters that can be used to determine the required orbital separation to ensure no more than a 6% increase in system noise temperature ( $\Delta T/T$ ) – a standard ITU coordination threshold – with varying assumptions as to the critical values of satellite transmit power levels, off-axis discrimination of the 17/24 GHz BSS satellite's transmit antenna, and noise temperature of the DBS satellite. The various scenarios modeled in that Annex show that the

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<sup>2</sup> See ITU-R BO.1835 ("Recommendation") (attached hereto as Appendix 1). This draft Recommendation has been approved by Study Group 6 and is currently in the administration approval process, which should be completed by the end of this year.

minimum orbital spacing between nominal locations of adjacent DBS and 17/24 GHz BSS satellites needed to meet a 6%  $\Delta T/T$  could be as little as  $0.12^\circ$  or as much as  $0.40^\circ$ .<sup>3</sup> The ITU urges all administrations in Region 2 to take into account the analyses and results contained in Annex 1 to the Recommendation when designing and deploying 17/24 GHz BSS networks.<sup>4</sup>

DIRECTV believes that the Commission should draw upon the Recommendation in fashioning its rules for this band. However, given the millions of American consumers who depend upon DBS signals for their video entertainment and the lack of actual experience with DBS and 17/24 GHz BSS satellites operating in close proximity, DIRECTV submits that the Commission should adopt the more conservative results of the analysis and require a minimum of  $0.40^\circ$  spacing.

Moreover, DIRECTV believes that a further consideration must be taken into account. Under the international plan for DBS operations (“DBS Plan”),<sup>5</sup> each administration is assigned DBS channels at one or more nominal orbital locations. However, this plan contemplates that DBS spacecraft may be located in a “cluster” within  $\pm 0.2^\circ$  of that nominal location.<sup>6</sup> Some of the DBS locations assigned to the U.S. have multiple satellites in operation, including three in use at both  $101^\circ$  W.L. and  $110^\circ$  W.L.<sup>7</sup> The number and exact position of satellites at various slots have changed over time as the

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<sup>3</sup> See Recommendation, Annex 1 at 4-7. These values assume that both spacecraft are tended to a station keeping tolerance of  $\pm 0.05^\circ$ .

<sup>4</sup> Recommendation at 3.

<sup>5</sup> ITU Radio Regs., App. 30/30A.

<sup>6</sup> See ITU Radio Regs., App. 30, Annex 7.B.

<sup>7</sup> There are also two non-DBS satellites operating at the nominal  $101^\circ$  W.L. location, making congestion even more acute within the DBS box.

operators' needs have changed. In order to maintain the required flexibility for operators to place their DBS satellites anywhere within this cluster – as contemplated under the international DBS Plan – this orbital real estate must be reserved for DBS satellite operations. Accordingly, for those DBS allocations that are currently in use,<sup>8</sup> the minimal orbital spacing required for 17/24 GHz BSS satellites should be measured from the edge of the orbital “box” defined by the nominal location of a DBS allocation  $\pm 0.2^\circ$ . When combined with the  $0.4^\circ$  spacing discussed above, the total minimum spacing from the nominal DBS location allocated under the DBS Plan should be  $0.6^\circ$ . Even this conservative approach would allow those operators who want to develop receive antennas capable of receiving both DBS and 17/24 GHz BSS signals with a single feed horn to operate their satellites in sufficiently close proximity to do so.<sup>9</sup>

In addition to this minimum orbital spacing requirement, DIRECTV supports the Commission's proposal to adopt an off-axis PFD coordination trigger of  $-93 \text{ dBW/m}^2/24 \text{ MHz}$  at a potentially affected DBS orbital location.<sup>10</sup> However, for the reasons described above, DIRECTV believes that 17/24 GHz BSS satellites should be required to coordinate if they exceed this PFD level at the edge of the DBS “box” extending  $\pm 0.2^\circ$  from the nominal DBS orbital location. This will ensure that DBS operators continue to have the flexibility envisioned under the DBS Plan to accommodate operation of multiple

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<sup>8</sup> DIRECTV does not believe that minimum spacing should be required for DBS Plan allocations that have not yet been brought into use, as they may never be used and would unnecessarily constrain deployment of 17/24 GHz BSS systems.

<sup>9</sup> EchoStar, the chief proponent of this approach, asserts that DBS and 17/24 GHz BSS satellites must be spaced no further than  $0.7^\circ$  apart in order to be received on a single feed horn. *See Sua Sponte Reconsideration Order*, ¶ 16. Effectively requiring  $0.6^\circ$  of separation from the center of a DBS cluster would place the satellites within that limit for all but a DBS satellite located on the very farthest side of the cluster away from the 17/24 GHz BSS satellite. Operators interested in this approach could arrange their DBS assets to achieve the necessary proximity.

<sup>10</sup> *FNPRM*, ¶ 184.

DBS satellites from a single nominal position. To the extent a 17/24 GHz BSS operator proposes to exceed this PFD level at the edge of the box, it must coordinate with all DBS licensees at the affected nominal slot before commencing operations.<sup>11</sup>

Because virtual co-location of satellites transmitting and receiving in the same band has not previously been an issue, the Commission has not previously required satellite applicants to provide off-axis transmitting antenna gain in the plane of the GSO arc or established rules for such gain. DIRECTV believes that 17/24 GHz BSS applicants should be required to provide detailed information – including measured data and summaries thereof in chart and/or graphic form over an angular range of  $\pm 90^\circ$  in the plane of the GSO arc – to enable DBS operators to assess the potential for interference and protect their operations in the future.<sup>12</sup> This requirement should apply to all such applicants – even those who do not initially intend to operate near a DBS orbital location – so that this vital information will be available should the satellite later be proposed for operation in close proximity with DBS satellites.

## **II. Ground Path Interference**

In this section, the focus changes to potential interference from DBS uplink transmissions to consumer and TT&C antennas trying to receive 17/24 GHz BSS downlink transmissions. As discussed below, DIRECTV believes that the Commission should grandfather existing DBS uplink sites within defined limits, and should establish rules for new sites that will minimize their potential for denying 17/24 GHz BSS service to residents living nearby.

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<sup>11</sup> DIRECTV believes that the combination of these two safeguards should also be sufficient to protect DBS TT&C operations as well. *See FNPRM*, ¶ 187.

<sup>12</sup> *FNPRM*, ¶ 185.

**A. Existing DBS Uplink Facilities.**

There are relatively few existing DBS feeder link earth stations, most of which are located in fairly remote areas of the country. Though few in number, these earth stations are a critical component of the DBS systems that provide video entertainment to tens of millions of American viewers every day. As the Commission has tentatively concluded,<sup>13</sup> licensed and operating DBS uplink facilities must be grandfathered so that they may continue to operate in the manner in which they were designed in reliance on the rules then in effect, and not be subjected to any new interference mitigation requirements imposed in this proceeding.

Accordingly, the Commission proposes to define a zone around each existing DBS uplink site within which 17/24 GHz BSS receive antennas cannot claim protection from their transmissions. DIRECTV supports such a “non-protection zone” approach. In DIRECTV’s view, the simplest method would be to define a zone where  $\Delta T/T$  of 6% into the 17/24 GHz BSS receiver would not be exceeded for normal feeder link and receive terminal characteristics. The parameter values in Table 1 represent such characteristics, and result in a required distance between a typical DBS feeder link and 17/24 GHz BSS receive terminal of approximately 30 km.

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<sup>13</sup> *FNPRM*, ¶ 151.

<b>Parameter</b>	<b>Units</b>	
Delta T/T Required	%	6.0
I/N Required	dB	-12.2
Frequency	GHz	17.5
Isotropic area	dB-m <sup>2</sup>	-46.3
DBS FL Ant. Gain	dBi	65.0
DBS FL TX Pwr	dBW	13.0
DBS FL EIRP	dBW	78.0
DBS FL xpndr BW	MHz	24.0
DBS FL angle to horizon	Deg.	40.0
25.209 off-axis gain	dBi	-8.1
DBS FL EIRP density toward horizon	dBW/Hz	-68.9
Rcv e/s angle to horizon	Deg.	20.0
E/S off-axis gain toward horizon (BO.1213)	dBi	-3.5
E/S sys. temp	K	150.0
E/S noise pwr density	dBW/Hz	-206.8
Io max from FL	dBW/Hz	-219.1
Required spreading loss	dB	-100.4
<b>Required distance from FL to e/s</b>	<b>km</b>	<b>29.4</b>
<b>PFD at receiver</b>	<b>dBW/m<sup>2</sup>/MHz</b>	<b>-109.2</b>

**Table 1. DBS Feeder-link Interference into  
17/24 GHz BSS Receive Antennas**

Based on this analysis, DIRECTV submits that 30 km would be an appropriate radius for the non-protection zone.<sup>14</sup>

The impact of these non-protection areas is likely to be less than it seems at first blush for several reasons. First, there are very few existing uplink sites. Second, those sites are, by and large, located in remote areas with very low population density. Third, those sites are likely to have some form of obstacles around them that would greatly

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<sup>14</sup> DIRECTV notes that more sophisticated propagation models exist that take into account RF phenomena (refraction, diffraction, atmospheric, terrain, etc.), such as the Longley-Rice model. Use of these models is more complicated than the free-space model and would generally yield larger separation distances to meet a required PFD.

attenuate the DBS signal.<sup>15</sup> Fourth, the uplink antennas are likely to be pointed at fairly high elevation angles, dramatically decreasing the energy transmitted toward the horizon. And fifth, many subscribers would be able to shield their receive antennas from the DBS uplink signals by, for example, mounting the antenna on the opposite side of the house. Thus, by no means should anyone expect that all those residing within the non-protection zone would be unable to receive 17/24 GHz BSS service.

As the Commission also recognizes, DBS operators must have some ability to upgrade facilities at existing uplink sites.<sup>16</sup> While upgrades to grandfathered facilities must be allowed so that DBS operators can continue to keep pace with technological advances, such upgrades should not be allowed to significantly degrade the interference environment for those receive antennas located outside the non-protection zone. DIRECTV believes that this balance can be achieved by limiting upgrades to existing facilities or new facilities located within 1 km of existing facilities.<sup>17</sup> Because the non-protection zone extends beyond the horizon, limiting upgrades to areas in and around existing uplink locations ensures that few if any antennas outside the non-protection zone will be affected by any modifications.<sup>18</sup> This approach is easy to administer and should reduce the number of new geographically diverse DBS uplink sites. It also obviates the need to undertake the complicated conceptual and technical analysis necessary to define

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<sup>15</sup> For example, DIRECTV's facility in Castle Rock, CO is located in a valley such that the natural contours of the land shield the surrounding area from its transmissions.

<sup>16</sup> *FNPRM*, ¶ 152.

<sup>17</sup> This aspect is similar to EchoStar's proposal to grandfather any new earth station built within a mile of a grandfathered site. *FNPRM*, ¶ 156.

<sup>18</sup> Any upgrade implemented beyond 1 km from an existing facility would be treated as a new earth station under the approach discussed in the next section.

an operational envelope for future modifications by establishing an appropriate PFD level at the boundary of the protection zone.<sup>19</sup>

***B. New DBS Uplink Facilities.***

Going forward, however, if DBS operators seek to build new feeder link facilities – especially after 17/24 GHz BSS systems have deployed – the calculus changes dramatically. At that point, it is the consumer’s (not the DBS operator’s) reasonable expectations that must be protected. In such a case, DIRECTV agrees with the Commission’s conclusion that proposed DBS feeder link operations should be coordinated with existing 17/24 GHz BSS users.<sup>20</sup> Moreover, the Commission could greatly facilitate this process by requiring new DBS uplink facilities to observe rules designed to limit their impact on potential 17/24 GHz BSS subscribers.

***1. Coordination***

DIRECTV supports the establishment of a coordination zone around new DBS uplink facilities in order to protect the interests of consumers receiving 17/24 GHz BSS service. The alternative approach suggested by EchoStar, in which a DBS operator could reduce even long-established 17/24 GHz BSS receive antennas to secondary status within a defined area wherever a new DBS uplink site was located, does not properly recognize the equities of the situation. DIRECTV also supports the Commission’s proposal to use the procedure in Table 9b of the *FNPRM* to establish the appropriate coordination zone.<sup>21</sup>

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<sup>19</sup> *FNPRM*, ¶ 157.

<sup>20</sup> *FNPRM*, ¶ 158.

<sup>21</sup> *FNPRM*, ¶ 161 and Table 9b. Whatever methodology the Commission chooses for coordination, the parameters used for analysis must assume that 17/24 GHz BSS receive antennas meet the Commission’s performance standards. The Commission’s rules already establish that a non-conforming receive antenna should not be protected beyond the level required to protect a conforming one. See 47 C.F.R. § 25.224.

However, DIRECTV believes that certain values proposed in Table 9b must be revised to better reflect typical parameters and thereby achieve a more appropriate coordination zone. Specifically, DIRECTV submits that:

- $p_0$  should be 0.03%, which translates to 99.7% availability for the 17/24 GHz BSS receive terminal (as a result,  $p$  becomes 0.015);
- $M_s$  should be 2 dB to protect feeder link stations in the Western states that have lower link margin;
- $\epsilon_{min}$  should be  $20^\circ$ , since no operator would be likely to place a feeder link station in an area with a lower elevation angle (such as  $5^\circ$ );
- $G_r$  should be 0, since the higher minimum elevation angle ( $20^\circ$ ) yields a lower gain toward the horizon for the 17/24 GHz BSS receive antenna; and
- $T_e$  should be 150 k, which is approximately the thermal noise temperature at the terminal of DIRECTV's Ka-band receive antennas operating in the 18.3-18.8 GHz band, and should be typical of 17/24 GHz BSS receive terminals.

Substituting these parameters, the permissible interference power value ( $P_r(p)$ ) becomes -148.2 dBW/MHz, as shown in the Revised Table 9b (with new parameters in bold).

**Revised Table 9b**

Parameter(s)		Value	Description
Orbit		GSO	Orbit in which the space service in which receiving earth station operates (GSO or NGSO)
Modulation at receiving earth station		N	Analog or digital
Receiving earth station interference parameters and criteria	$p_0$ (%)	<b>0.03</b>	Percentage of the time during which interference from all sources may exceed the threshold value
	$N$	2	Number of equivalent, equal level, equal probability entries of interference, assumed to be uncorrelated for small percentages of the time
	$p$ (%)	<b>0.015</b>	Percentage of the time during which the interference from one source may exceed the permissible interference power value; since the entries of interference are not likely to occur simultaneously, $p=p_0/n$
	$N_L$ (dB)	1	Link noise contribution
	$M_s$ (dB)	<b>2</b>	Link performance margin
	$W$ (dB)	0	A thermal noise equivalence factor for interfering emissions in the reference bandwidth; it is positive when the interfering emissions would cause more degradation than thermal noise
Receiving earth station parameters	$G_m$ (dBi)	36	On-axis gain of the receive earth station antenna
	$G_r$	<b>0</b>	Horizon antenna gain for the receive earth station
	$\epsilon_{min}$	<b>20°</b>	Minimum elevation angle of operation in degrees
	$T_e$ (K)	<b>150K</b>	The thermal noise temperature of the receiving system at the terminal of the receiving antenna. <i>See</i> § 2.1 of Annex 7 to Appendix 7 of the ITU Radio Regulations which provides a default value for two earth stations operating in opposite directions of transmission at frequencies greater than 17/24 GHz.
Reference Bandwidth	$B$ (Hz)	$1.0 \times 10^6$	Reference bandwidth (Hz), i.e., the bandwidth in the receiving station that is subject to the interference and over which the power of the interfering emission can be averaged.
Permissible interference power	$P_r(p)$ (dB W) in $B$	-148.2	Permissible interference power of the interfering emission (dBW) in the reference bandwidth to be exceeded no more than p% of the time at the receiving antenna terminal of a station subject to interference, from a single source of interference, using the formula: $P_r(p) = 10 \log(k T_e B) + N_L + 10 \log(10^{M_s/10} - 1) - W$

Having defined the zone subject to a coordination obligation, the Commission should implement a process similar to that already developed for sharing in the 12 GHz band used by DBS and MVDDS operators. Accordingly, DIRECTV supports the Commission's proposal to adopt service rules similar to those in Section 25.203(c), requiring all applicants for new DBS uplink facilities to complete prior coordination with existing and planned 17/24 GHz BSS receiving earth stations.<sup>22</sup> DIRECTV also supports the proposals to use a neutral, third-party frequency coordinator to handle the review of sensitive subscriber data and to require applicants to provide to the qualified frequency coordinator the types of information currently called for under Section 25.203(c)(2) of the Commission's rules.<sup>23</sup>

## *2. Interference Mitigation*

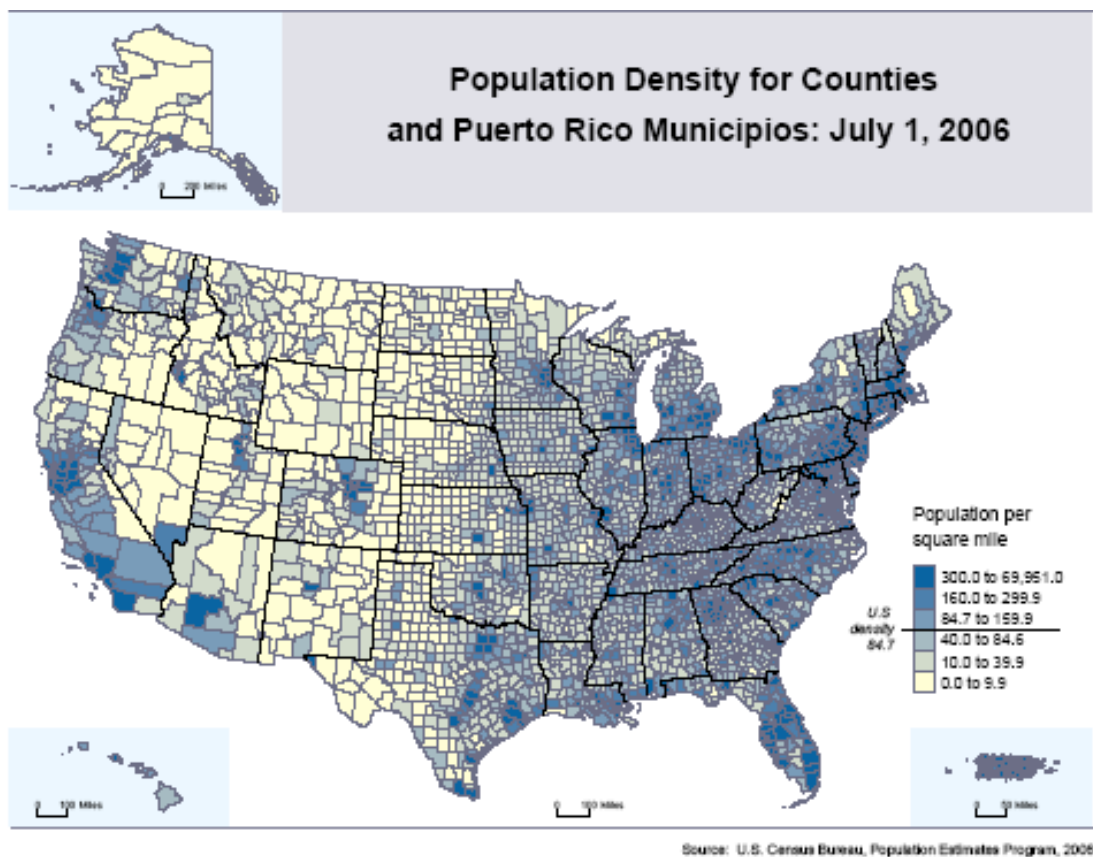
DIRECTV also believes that the Commission should require DBS operators to locate new uplink sites in areas of low population density and to operate within a specified PFD level at such locations. These requirements will minimize the number of 17/24 GHz BSS subscribers whose ability to receive service could be compromised by construction of a new DBS uplink facility. In addition, it will have the effect of minimizing the coordination zone around such facilities, thereby minimizing the coordination burden on DBS operators. Nor should these requirements be a great imposition, as existing DBS uplink sites are mostly located in sparsely populated areas and shielding is achieved fairly easily in new construction.

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<sup>22</sup> *FNPRM*, ¶ 167.

<sup>23</sup> *FNPRM*, ¶¶ 168-69.

In determining which areas should be available for construction of new DBS uplink facilities, the Commission should rely upon the most recent data collected by the U.S. Census – clearly an authoritative and neutral source. DIRECTV proposes that new sites be located only in areas with a population density lower than 10 people per square mile. The map in Figure 2 below, created from July 2006 data, illustrates that a large portion of the country meets this criterion.



**Figure 2. U.S. Population Density**

In addition, DIRECTV proposes that new uplink facilities be required to erect RF shielding, or locate antennas in areas where natural shielding provides at least 10 dB of attenuation, so as not to exceed a specified PFD level. Using the parameter values from Table 1 in Section II A above, adding 10 dB of artificial or natural shielding achieves the

same PFD level of  $-109.2 \text{ dBW/m}^2/\text{MHz}$  at only 9.3 km. Accordingly, and rounding off the numbers a bit for simplicity, DIRECTV proposes that new DBS uplink facilities be required not to exceed a PFD of  $-109 \text{ dBW/m}^2/\text{MHz}$  at any point beyond a radius of 10 km. This approach will minimize the impact of new DBS uplink facilities on existing 17/24 GHz BSS subscribers in areas surrounding uplink sites.

Applying these requirements also has another valuable benefit. The Commission has yet to license its first 17/24 GHz BSS satellite system. Even were those licenses to be issued in the next few months, construction and launch of the first satellite is likely three or more years away. By requiring new DBS uplinks to be built in remote areas and to meet a PFD limitation, the Commission will ensure that the areas where such new construction will make receipt of 17/24 GHz BSS signals problematic will be kept to a minimum. DIRECTV believes it is important to maintain opportunities for this nascent service in this way.

## CONCLUSION

The *FNPRM* raises important spectrum sharing issues that will affect the operations of both DBS and 17/24 GHz BSS operators. DIRECTV submits that the approaches discussed herein strike an appropriate balance between the interests of protecting an incumbent service and nurturing a nascent one, and urges the Commission to adopt them expeditiously so that this new band can be put to productive use as soon as possible.

Respectfully submitted,

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## **APPENDIX 1**



INTERNATIONAL TELECOMMUNICATION UNION

**RADIOCOMMUNICATION  
STUDY GROUPS**

**Document 6/BL/45-E  
27 August 2007  
English only**

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Subject: Question ITU-R 70/6

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## **Radiocommunication Study Group 6**

DRAFT NEW RECOMMENDATION ITU-R BO.[Doc. 6/383]

### **Sharing between broadcasting-satellite service (BSS) networks using the Region 2 17.3-17.8 GHz BSS allocation and feeder links of BSS networks using the worldwide 17.3-17.8 GHz fixed-satellite service (FSS) (Earth-to-space) allocation**

#### **Summary**

This Recommendation is intended to help facilitate the design and coordination of new Region 2 BSS networks that will use the 17.3-17.8 GHz BSS allocation that took effect on 1 April 2007. Annex 1 to the Recommendation provides detailed parametric analyses of the two cases where coordination of such networks might be required with BSS networks that use the worldwide 17.3-17.8 GHz FSS (Earth-to-space) allocation for feeder links. The results shown in this Recommendation demonstrates that close orbital spacing can be achieved, while still meeting a  $\Delta T/T$  criterion of 6%, if the results of these analyses are considered in the design of Region 2 satellites.

#### **Vocabulary**

None.

## DRAFT NEW RECOMMENDATION

### **Sharing between broadcasting-satellite service (BSS) networks using the Region 2 17.3-17.8 GHz BSS allocation and feeder links of BSS networks using the worldwide 17.3-17.8 GHz fixed-satellite service (FSS) (Earth-to-space) allocation**

#### **Scope**

This Recommendation addresses the design and coordination of new Region 2 BSS networks that will use the 17.3-17.8 GHz BSS allocation that took effect on 1 April 2007. Annex 1 to the Recommendation provides detailed parametric analyses of the two cases where coordination might be required with BSS networks that use the worldwide 17.3-17.8 GHz FSS (Earth-to-space) allocation for feeder links. The substance of the Recommendation is that coordination may not be required if the results of these analyses are taken into account in the design of Region 2 BSS networks intended for use in this new BSS allocation.

The ITU Radiocommunication Assembly,

*considering*

- a) that, in all three ITU Regions, the 17.3-17.8 GHz band is subject to the BSS feeder-link Plans of Appendix 30A of the Radio Regulations;
- b) that the 17.3-17.8 GHz band is also allocated to BSS in Region 2;
- c) that there is the possibility of interference from the Region 2 BSS transmitting satellite to Regions 1, 2 and 3 BSS feeder-link receiving satellites operating under Appendix 30A of the Radio Regulations;
- d) that Annex 4 of Appendix 30A of the Radio Regulations provides threshold values for determining when coordination is required between transmitting space stations in the broadcasting-satellite service and a receiving space station in the feeder-link Plans in the frequency band 17.3-17.8 GHz;
- e) that the criterion for determining when coordination is required is that the power flux-density from the Region 2 BSS transmit satellite arriving at the receiving space station of a broadcasting-satellite feeder link of another administration would cause an increase in the noise temperature of the feeder-link space station which exceeds a threshold value of  $\Delta T/T$  corresponding to 6%;
- f) that there may be unacceptable interference in the case of closely spaced Region 2 BSS transmit satellites and BSS feeder-link receive satellites, or in the case of interference from a Region 2 BSS satellite to a receive BSS feeder-link satellite located across the limb of the Earth,

*recognizing*

- 1 that studies described in Annex 1 show that very close spacing is feasible between Region 2 BSS satellites and BSS feeder-link receive satellites without exceeding the criterion contained in Annex 4 of Appendix 30A of the Radio Regulations;
- 2 that studies described in Annex 1 show that interference across the limb of the Earth is limited to very few geometric scenarios that may not occur in practice;

**3** that the key parameters in determining the proximity with which Region 2 BSS satellites and BSS feeder-link receive satellites could be deployed are the off-axis gain discriminations of the transmitting and receiving satellite antennas, the peak transmitting satellite equivalent isotropically radiated power (e.i.r.p.) levels, and the receiving satellite system noise temperature,

*recommends*

**1** that administrations in Region 2 should take into account the analyses and results contained in Annex 1 when designing and deploying BSS networks in the 17.3-17.8 GHz band.

## **Annex 1**

### **Parametric analyses on sharing between BSS networks using the Region 2 17.3-17.8 GHz BSS allocation and feeder links of BSS networks using the worldwide 17.3-17.8 GHz FSS (Earth-to-space) allocation**

#### **1 Introduction**

The Region 2 allocation for the broadcasting-satellite service (BSS) in the 17.3-17.8 GHz band came into effect on 1 April 2007. This BSS band is paired with the 24.75-25.25 GHz FSS (Earth-to-space) band for its feeder links. The 17.3-17.8 GHz band, in accordance with Appendix 30A, is also allocated in the Earth-to-space direction for feeder links to the Appendix 30 12 GHz BSS networks in all three Regions. The term “reverse-band” typically refers to the situation where a frequency band is used for both Earth-to-space and space-to-Earth transmissions. The BSS networks operating under Appendices 30 and 30A are referred to as “17/12 GHz” networks, while those operating in the 17 GHz Region 2 BSS allocation are referred to as “24/17 GHz” networks.

This 17.3-17.8 GHz reverse-band operation creates the potential for the two interference paths illustrated schematically in Fig. 1: 1) between the transmitting space stations and the receiving space stations in the 17 GHz band (satellite-to-satellite), and 2) between the transmitting feeder-link earth stations and the receiving earth stations in the 17 GHz band. This document addresses only the satellite-to-satellite case.

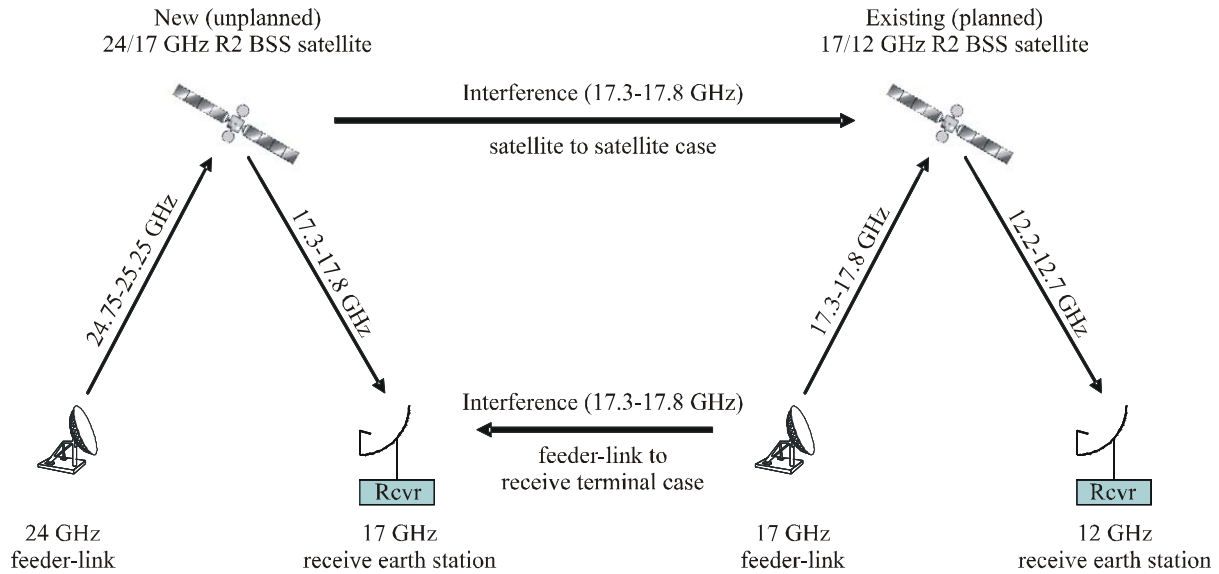
The satellite-to-satellite interference path will occur when the signals from the transmitting 24/17 GHz satellite impinge on the receiving antenna of the 17/12 GHz satellite in 17.3-17.8 GHz. The amount of interference is determined by the physical separation between the satellites, the e.i.r.p. level of the transmitting 24/17 GHz BSS satellite, the off-axis gains of the 17 GHz transmitting and receiving satellite antennas towards each other, and the noise temperature of the receiving satellite.

The criterion for determining if coordination is required between a transmitting space station of a 24/17 GHz network and a receiving space station of a 17/12 GHz network is provided in Section 1 of Annex 4 of Appendix 30A of the Radio Regulations, and is defined as a  $\Delta T/T$  of 6%.

There are two cases for this potential interference: 1) the adjacent-satellite case, where the 17/12 GHz and 24/17 GHz satellites are closely spaced along the orbital arc, and 2) the equatorial-limb case, where the 17/12 GHz and 24/17 GHz satellites are separated by approximately 162.6 degrees along the orbital arc, i.e. across the equatorial limb of the Earth. Analyses for these two cases are presented below in Sections 2 and 3, respectively.

FIGURE 1

### Reverse-band operation and interference paths for Region 2 BSS and feeder links



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## 2 Adjacent-satellite case

This section addresses closely-spaced satellites. A parametric analysis was conducted to determine the required orbital separation between a 24/17 GHz transmitting BSS space station and a 17/12 GHz receiving BSS space station that are located very close to each other along the geostationary arc. The key operational parameters in determining the required separation in order to meet the  $\Delta T/T$  of 6% condition are the transmit e.i.r.p. of the 24/17 GHz satellite, the off-axis discriminations of the transmit and receive satellite antennas, and the receive satellite noise temperature of the 17/12 GHz satellite.

The off-axis angle relative to boresight for both transmit and receive antennas is approximately 90 degrees. These large off-boresight angles lead to antenna off-axis gains that are substantially below the peak of the boresight gain. Examination of published diagrams for receive gain toward the GSO arc for Region 2 assignments and modifications shows typical values between 0 and -5 dBi. These diagrams envelope the actual receive antenna patterns.

The 17/12 GHz assignments that may be affected are the current Region 2 Plan feeder-link assignments whose technical parameters are specified in Appendix 30A of the Radio Regulations and its subsequent modifications. For the satellite receive antenna, the characteristics, e.g. noise temperature and off-axis satellite gain, of the original Region 2 Plan are used in the analysis. The Region 2 Plan specifies a receive noise temperature of 1 500 K. Additionally, Section 3.7.3 of Annex 3 of Appendix 30A of the Radio Regulations assumes that, for off-axis angles greater than

approximately 20 degrees, the receive off-axis satellite antenna discrimination is equal in magnitude, but of opposite sign, to the peak gain of the antenna. Therefore, this analysis assumed an off-axis receive gain of 0 dBi towards the adjacent satellite, although in reality there is likely to be more discrimination.

Given that the 24/17 GHz satellite transmit power could be relatively high due to the use of spot beams to cover small geographic areas, the parametric analysis considered peak e.i.r.p. values from 55 dBW to 65 dBW. In addition, for the 24/17 GHz transmit antenna, values of off-axis discrimination in the range 40 to 60 dB were assumed. Finally, three values of receive system noise temperature were taken into account. The results are presented in the following three tables.

TABLE 1  
Varying interfering satellite peak e.i.r.p.

Line #	Parameter	Units	Case 1	Case 2	Case 3
1	R2 assignment system temp.	dBK	31.8	31.8	31.8
2	Boltzmann's Constant	dB(W/K/Hz)	-228.6	-228.6	-228.6
3	Noise power density ( $N_0$ )	dB(W/Hz)	-196.8	-196.8	-196.8
4	Frequency	GHz	17.5	17.5	17.5
5	Isotropic area	dB(m <sup>2</sup> )	-46.3	-46.3	-46.3
6	17 GHz transponder bandwidth	MHz	24.0	24.0	24.0
7	Victim satellite receive gain toward interferer	dBi	0.0	0.0	0.0
8	Interfering satellite peak e.i.r.p.	dBW	55.0	60.0	65.0
9	TX off-axis discrimination of interfering satellite	dB	50.0	50.0	50.0
10	Resultant orbital separation between satellites	deg.	0.02	0.03	0.06
11	Orbital separation in km	km	14.1	25.0	44.4
12	Spreading loss	dB	93.9	98.9	103.9
13	Interfering receive power	dBW	-135.3	-135.3	-135.3
14	$I_0/N_0$	dB	-12.2	-12.2	-12.2
15	Delta $T/T$	%	6.0	6.0	6.0

Table 1 shows the required orbital separations to meet a  $\Delta T/T$  of 6% for varying 24/17 GHz satellite transmit e.i.r.p. levels. The peak e.i.r.p.s range from 55 to 65 dBW (Line 8). The corresponding required orbital separations are shown both in degrees (Line 10) and in km (Line 11). Using the highest e.i.r.p. of 65 dBW, a reasonable off-axis discrimination of 50 dB, and a receive system noise temperature of 31.8 dBK (1 500 K), the required separation distance is 0.06 degrees. If a station-keeping tolerance of  $\pm 0.1$  degree is added for each satellite, the minimum orbital separation between nominal locations to meet a 6%  $\Delta T/T$  would be 0.26 degrees.

TABLE 2  
Varying interfering satellite off-axis discrimination

Line #	Parameter	Units	Case 4	Case 5	Case 6
1	R2 assignment system temp.	dBK	31.8	31.8	31.8
2	Boltzmann's Constant	dB(W/K/Hz)	-228.6	-228.6	-228.6
3	Noise power density ( $N_0$ )	dB(W/Hz)	-196.8	-196.8	-196.8
4	Frequency	GHz	17.5	17.5	17.5
5	Isotropic area	dB(m <sup>2</sup> )	-46.3	-46.3	-46.3
6	17 GHz transponder bandwidth	MHz	24.0	24.0	24.0
7	Victim satellite receive gain toward interferer	dBi	0.0	0.0	0.0
8	Interfering satellite peak e.i.r.p.	dBW	65.0	65.0	65.0
9	TX off-axis discrimination of interfering satellite	dB	40.0	50.0	60.0
10	Orbital separation between satellites	deg.	0.19	0.06	0.02
11	Orbital separation in km	km	140.5	44.4	14.1
12	Spreading loss	dB	113.9	103.9	93.9
13	Interfering receive power	dBW	-135.3	-135.3	-135.3
14	$I_0/N_0$	dB	-12.2	-12.2	-12.2
15	Delta $T/T$	%	6.0	6.0	6.0

Table 2 shows the variation in required separation distance (Lines 10 and 11) in order to maintain a  $\Delta T/T$  of 6% while the transmit antenna discrimination was varied from 40 to 60 dB (Line 9). In this case, the 24/17 GHz satellite peak transmit e.i.r.p. was held constant at 65 dBW. For the worst case of only 40 dB of transmit antenna discrimination, the required orbital separation is 0.19 degrees. Again, adding the maximum  $\pm 0.1$  degree station-keeping error for each satellite yields 0.39 degrees separation between satellite centers.

TABLE 3  
Varying receive 12/17 GHz satellite noise temperature

Line #	Parameter	Units	Case 7	Case 8	Case 9
1	R2 assignment system temp.	dBK	31.8	29.5	27.8
2	Boltzmann's Constant	dB(W/K/Hz)	-228.6	-228.6	-228.6
3	Noise power density ( $N_0$ )	dB(W/Hz)	-196.8	-199.1	-200.8
4	Frequency	GHz	17.5	17.5	17.5
5	Isotropic area	dB(m <sup>2</sup> )	-46.3	-46.3	-46.3
6	17 GHz transponder bandwidth	MHz	24.0	24.0	24.0
7	Victim satellite receive gain toward interferer	dBi	0.0	0.0	0.0
8	Interfering satellite peak e.i.r.p.	dBW	65.0	65.0	65.0
9	TX off-axis discrimination of interfering satellite	dB	40.0	40.0	40.0
10	Orbital separation between satellites	deg.	0.19	0.25	0.30
11	Orbital separation in km	km	140.5	181.5	222.2
12	Spreading loss	dB	113.9	116.2	117.9
13	Interfering receive power	dBW	-135.3	-137.5	-139.2
14	$I_0/N_0$	dB	-12.2	-12.2	-12.2
15	Delta $T/T$	%	6.0	6.0	6.0

Table 3 shows the required orbital separations for receive system noise temperatures of 1 500 K, 900 K and 600 K. The peak interfering e.i.r.p. was held constant at 65 dBW and the off-axis discrimination was held constant at 40 dB. The worst-case orbital separation is 0.30 degree, or 0.50 degrees with maximum station-keeping tolerances.

These results show that only a very closely spaced 24/17 GHz satellite will likely cause an exceedance of the allowed  $\Delta T/T$  level of 6% toward receiving 17/12 GHz satellites. The design of 24/17 GHz satellite networks should strive to take the results of these analyses into account in order to avoid unnecessary coordinations with 17/12 GHz assignments and modifications in the Region 2 Plan. It is noted that many satellites in Region 2 operate with station keeping of  $\pm 0.05$  degree, rather than 0.1 degree. This would reduce all of the above total orbital separations by either 0.05 or 0.1 degree, depending on whether one or both satellites had the tighter station-keeping.

### 3 Equatorial-limb case

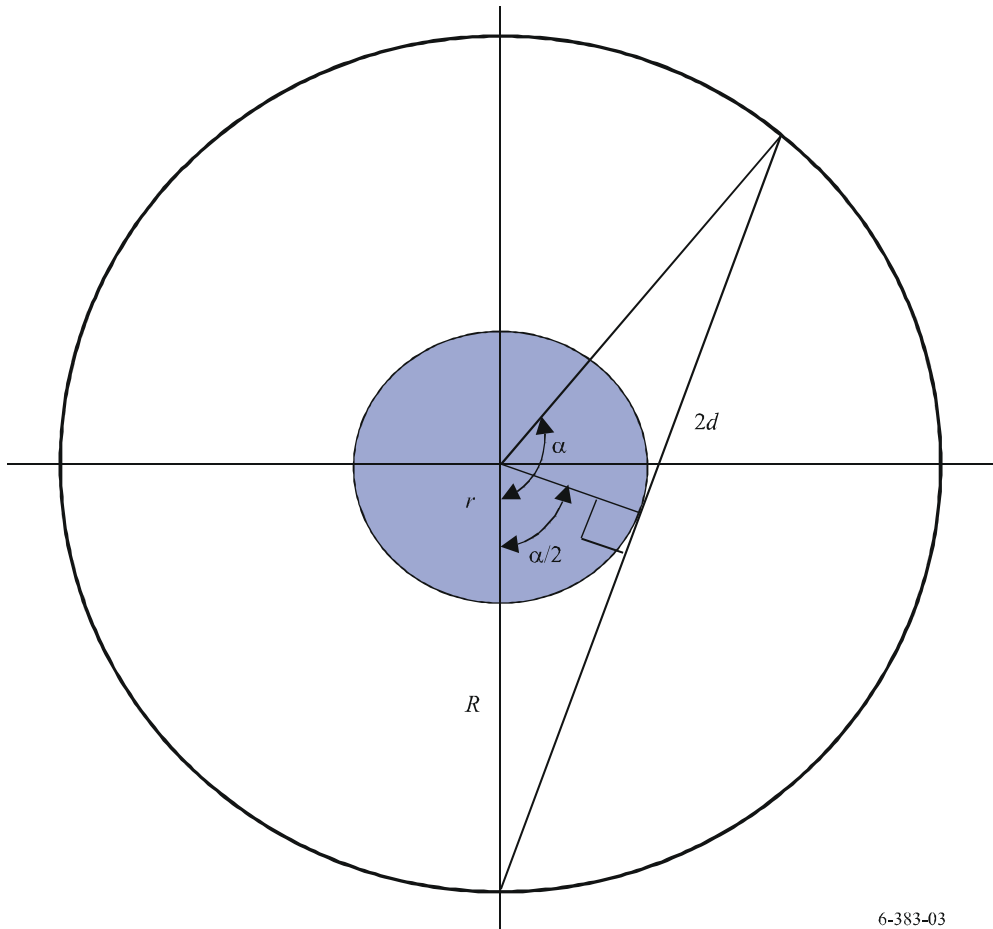
The equatorial-limb case is the case in which the interference path from a Region 2 transmitting 24/17 GHz satellite to a Region 1 or 3 receiving 17/12 GHz satellite grazes the limb of the Earth. Figure 2 depicts this configuration. The angle between the transmitting and receiving satellites is approximately 162.6 degrees, and the straight-line distance between the transmitting and receiving satellites for this case is 83 362 km or less. Figures 2 and 3 show the geometry for this case.

FIGURE 2

**Overlapping transmit and receive beams for equatorial-limb case**



FIGURE 3  
Equatorial limb geometry



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In the above Figs 2 and 3 the following applies:

$R$  = GSO altitude = 35 796 km

$r$  = radius of the Earth = 6 370 km

$$r/(r + R) = \cos(\alpha/2)$$

$$\alpha/2 = 81.3^\circ; \alpha = 162.6^\circ$$

$$2d = 2(r + R)\sin(\alpha/2) = 83\,362 \text{ km}$$

When the geometry of the equatorial-limb interference case is examined, it is clear that there exists only a small number of combinations of transmit/receive coverage areas and orbit locations that have the potential for interference. Limb-of-the-Earth interference is only possible when a Region 2 24/17 GHz transmitting satellite and a Region 1 or 3 17/12 receiving satellite serve countries close to the equator, and have appreciable amounts of off-axis antenna gains in the equatorial plane. In Regions 1 and 3, there are only a comparatively few broadcasting-satellite service areas that are near the equator. These include those for Indonesia, Australia, Papua New Guinea, India and countries in Central Africa.

In order to have any appreciable interference across the limb of the Earth from a Region 2 24/17 GHz transmitting satellite into a Region 1 or 3 17/12 GHz receiving satellite, all of the following conditions would have to occur:

- transmitting satellite beam covers Central America or equatorial South America;
- appreciable transmit power in the equatorial plane, i.e. low arrival angle of the transmit beam;
- receiving satellite beam covers equatorial or sub-tropical countries;
- appreciable receive gain in the equatorial plane, i.e. low arrival angle of the receive beam.

The spreadsheet below calculates the  $\Delta T/T$  interference into a Region 3 Plan assignment from a fictional Region 2 24/17 GHz transmitting satellite. The Region 3 INDA\_101 assignment was used in this analysis. The off-axis receive gain (Line 7) was obtained using GIMS. Even with a high interfering e.i.r.p. value of 65 dBW and no off-axis gain discrimination at the edge of the Earth, the  $\Delta T/T$  is less than 1%. This highly conservative example demonstrates that the chance for any appreciable limb-of-the-Earth interference is extremely small.

TABLE 4  
Calculation of  $\Delta T/T$  for equatorial-limb case

Line #	Parameter	Units	
1	R1/3 assignment system temp.	dBK	27.8
2	Boltzmann's Constant	dB(W/K/Hz)	228.6
3	Noise power density ( $N_o$ )	dB(W/Hz)	-200.8
4	Frequency	GHz	17.5
5	Isotropic area	dB(m <sup>2</sup> )	-46.3
6	17 GHz transponder bandwidth	MHz	24.0
7	Region 1/3 satellite receive gain toward interferer	dB	0.7
8	Interfering satellite peak e.i.r.p.	dBW	65.0
9	TX off-axis discrimination of interfering satellite	dB	0.0
10	Orbital separation between satellites	deg.	162.6
11	Orbital separation in km	km	83 361.7
12	Spreading loss	dB	169.4
13	Interfering receive power	dBW	-150.1
14	$I_0/N_0$	dB	-23.0
15	Delta $T/T$	%	<b>0.5</b>

#### 4 Conclusions

The parametric analyses presented in this Annex show that the potential for interference from a transmitting 24/17 GHz BSS satellite in Region 2 into 17/12 GHz satellites operating under Appendices 30 and 30A in any Region is only possible in two scenarios. One (the adjacent-satellite case) is when the transmitting and receiving satellites are very closely spaced, and the other (the equatorial-limb case) is when the transmitting and receiving satellites are in "opposition" across the geostationary orbital arc.

In the case of the adjacent satellites, care must be taken in the design of the 24/17 GHz satellites such that the transmit power in the direction of the orbital arc (i.e. roughly 90 degrees) is sufficiently low to avoid interfering with nearby 17/12 GHz receiving satellites, as shown in parametric Tables 1 through 3. For this case, it was shown that with reasonable operating characteristics, transmitting and receiving satellites can be spaced 0.02 to about 0.3 degrees apart, not including station-keeping.

For the equatorial-limb case, the likelihood of any significant interference can be avoided with only modest precautions, such as keeping arrival angles to service areas above 20 degrees, and reducing the amount of spillover power transmitted towards the orbital arc.

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